



FRED DUNCAN

# PROTACTINIUM

Element Symbol: **Pa**

Atomic Number: **91**

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Protactinium has the symbol Pa, and is the ninety first element of the periodic table. In a pure form, it would be a dense, silver-grey metal – but it is extremely rare with an average concentration in the Earth's crust of a few parts per trillion.

There are several known isotopes of Protactinium, all of which are intrinsically unstable and undergo radioactive decay with half lives ranging from minutes up to many thousands of years. The most common isotope (with 99.9% natural abundance) is Pa-231, a member of the Uranium-235 decay series with a half life of 32700 years, while other less common forms are found as members of Thorium and U-238 decay chains. The element does not exist in nature except as a member of decay series', and has no known uses outside of scientific research although it is used as a marker in the radiometric dating of sediments. In 1961 the UK Atomic Energy Agency extracted 125g of Protactinium from 60 tonnes of spent reactor fuel at a cost of half a million \$US, which for many years comprised the entire known world stocks of the pure element. More recently, Oak Ridge National Laboratory in the US has been producing Pa for research purposes at a cost of approximately \$280/gram.

Protactinium-231 decays by the emission of an alpha particle to Actinium – other isotopes (which exist only in trace amounts) decay by the emission of a beta particle. The radioactive nature of Protactinium means that it is highly toxic, but it's scarcity in nature means that any risk is insignificant. The high toxicity of the pure form means that all work is undertaken in a sealed 'glove-box' at scientific facilities.

Elements falling either side of Protactinium in the periodic table had been identified before it was itself discovered and Mendeleev predicted that an element existed with an atomic number of 91 which would fill the remaining gap between Thorium and Uranium in 1871, while producing the first version of the periodic table of elements. For some time before it was properly observed it went by the handle Uranium X2, denoting it as the second element of the Uranium decay chain.

There is some conjecture about who was first responsible for the discovery of Protactinium: first identified in 1913 and named Brevium for the Greek brevis=short-lived, a more stable isotope was discovered independently by two separate teams in 1917 and 1918 and named Protoactinium from the Greek protos = first/before Actinium, the element to which Pa decays after undergoing nuclear decay. Actinium, in turn, is named for the Greek aktino = ray. The 'o' of proto was dropped in 1949 to remove the clumsiness in pronunciation.

*Provided by the element sponsor Alice Jagger*

## ARTISTS DESCRIPTION

Protactinium occurs in nature as an unstable member of a radioactive decay series- it occurs before (hence "proto") the element Actinium (from the Greek "actino", meaning "ray"). My first mental image was of the Praetorian Guard- the elite Roman regiment charged with guarding the emperor and taking a major role in many campaigns. The print features an officer, advancing with a sword drawn under the regimental standard- in this case featuring the atomic structure of the element. A ray of light behind the officer indicates the relationship of Protactinium with Actinium in the command chain of nuclear decay. The printmaking technique is a dry-point engraving on an acetate plate, with red highlight being added by a watercolour wash.

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